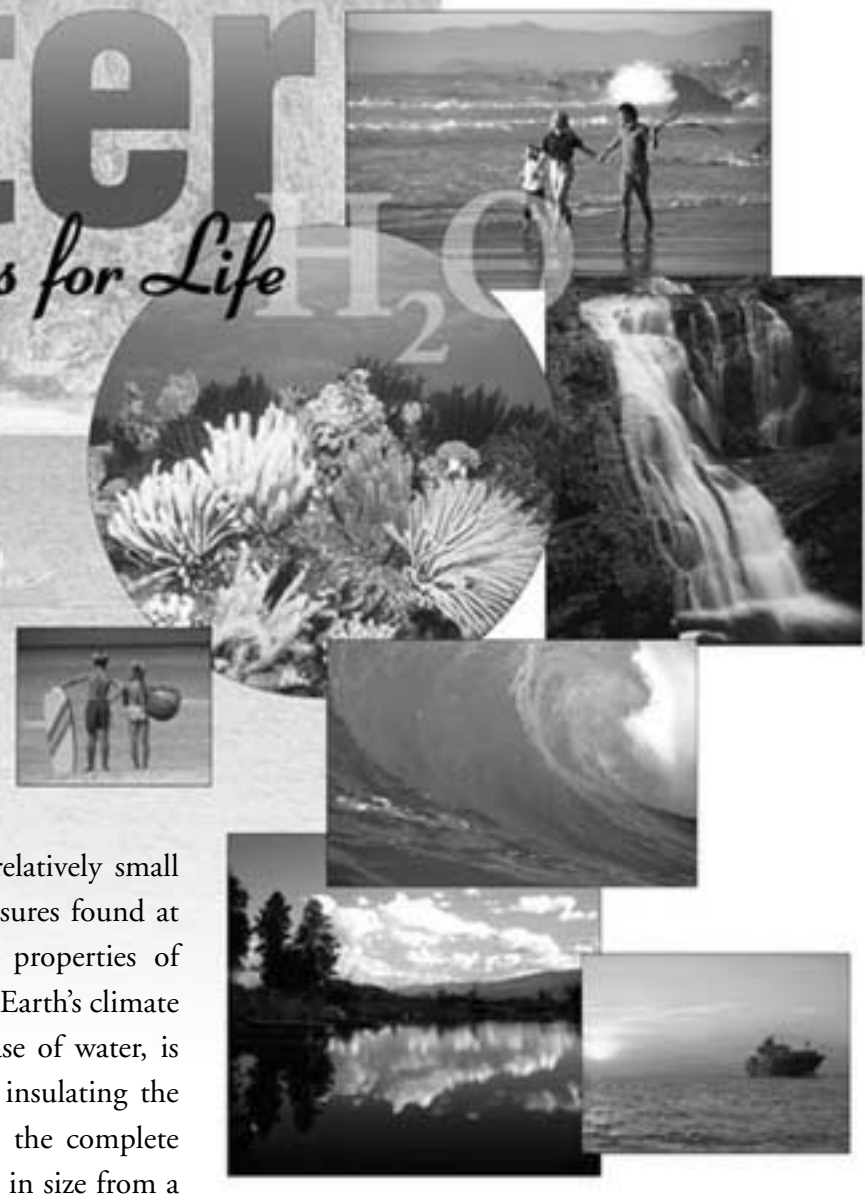
Water

The Basis for Life



Water is pervasive on Earth and is the only known substance that naturally exists as a gas, liquid, and solid within the relatively small range of air temperatures and pressures found at the Earth's surface. The unusual properties of water have profound effects on the Earth's climate and ecosystems. Ice, the solid phase of water, is less dense than water so it floats, insulating the water underneath, which prevents the complete freezing of bodies of water ranging in size from a small pond to the Arctic Ocean. This insulating effect enables the water below the ice to sustain life through the harshest of winters. Water has the capacity to store large amounts of heat and transport this heat over vast distances via ocean currents. Water's ability to act as a solvent for most substances, including nutrients, enables both animal and plant life to survive; and the capacity for the gaseous phase, water vapor, to store and release latent heat leads to such weather events as the formation of rain and clouds, and more dramatically, events such as hurricanes and tornadoes.

National Aeronautics and Space Administration
For more information contact:
EOS Project Science Office, Code 900
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
NW-2002-2-027-GSFC

The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

Our World of Water — A Mission Sampler

Terra Mission

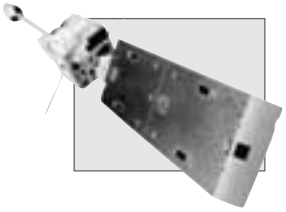
The Terra mission, launched in December 1999, carries five instruments, one of which provides significant contributions to water studies, the Moderate Resolution Imaging Spectroradiometer (MODIS). MODIS provides a comprehensive series of global observations every two days at spatial resolutions up to 250 meters (820 feet). MODIS measures the type and extent of ocean chlorophyll, pigment concentration and water-leaving radiance. These measurements are used to study ocean currents, upwelling, and air-sea interaction.

Aqua Mission

The Aqua mission, scheduled to launch in spring 2002, will carry six instruments, two of which provide significant contributions to water studies. These are MODIS, also on Terra, and the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E). AMSR-E will monitor water vapor profiles, precipitation, water vapor distribution, cloud water, and a variety of other climate variables. The instrument was contributed to the EOS program by the National Space Development Agency (NASDA) of Japan.

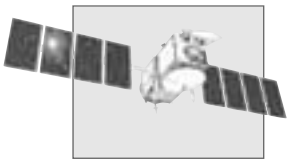
NOAA Polar Orbiting Satellites

Since 1978, the National Oceanic and Atmospheric Administration (NOAA) and NASA have jointly developed the polar-orbiting Earth environmental observation satellites that carry the Advanced Very High Resolution Radiometer (AVHRR) instrument. They have provided data for immediate needs (including images for television news programs) as well as extensive climate research.



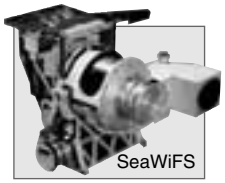
NOAA Geostationary Operational Environmental Satellites

NOAA's Geostationary Operational Environmental Satellites (GOES) circle the Earth in a geosynchronous orbit 35,800 kilometers (approximately 22,100 miles) above the Earth, at a speed matching the Earth's rotation. This allows them to hover continuously over one position on the Earth's surface providing a constant vigil for the atmospheric triggers of severe weather events such as tornadoes, flash floods, hailstorms and hurricanes.



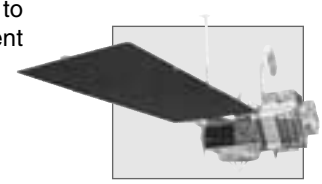
Jason-1 Mission

The instruments aboard Jason-1, a collaborative effort between NASA and the French Centre National d'Etudes Spatiales, will map sea surface topography, measure ocean wave heights, wind speeds, and water vapor. These data will be used to study the ocean's role in global changes in climate and the variations in sea level in response to global warming/cooling.



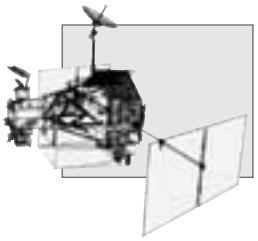
OrbView-2 Mission

The Sea-viewing Wide Field-of-View Sensor (SeaWiFS) aboard ORBIMAGE's OrbView-2 satellite provides data to study subtle changes in ocean color which signify various types and quantities of marine phytoplankton (microscopic marine plants), the knowledge of which has both scientific and practical applications. Color in most of the world's oceans varies with the concentration of chlorophyll and other plant pigments present in the water. NASA purchases SeaWiFS data for research and educational purposes.



TOPEX/Poseidon – Topography Experiment

Data from TOPEX/Poseidon, a joint U.S./French mission, enable early warnings of El Niño and La Niña weather patterns that have caused devastating floods in some areas and drier than normal periods in others. TOPEX/Poseidon monitors global ocean circulation and helps improve global climate predictions. Data applications include ship routing, and commercial fishing.



Tropical Rainfall Measuring Mission

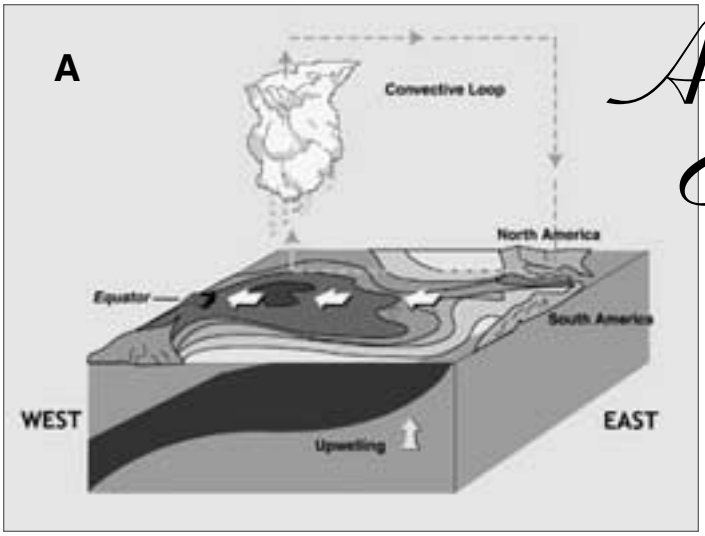
The Tropical Rainfall Measuring Mission (TRMM) is the first mission dedicated to measuring tropical and subtropical rainfall through microwave and visible infrared sensors, including the first spaceborne rain radar. TRMM is a joint project between the U. S. and Japan. Tropical rainfall comprises more than two thirds of global rainfall and is the primary driver of global atmospheric circulation as a heat source.

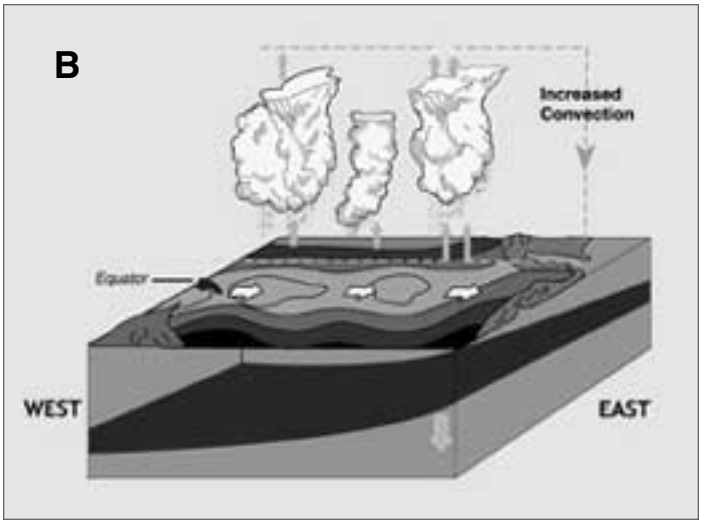
National Aeronautics and Space Administration
For more information contact: EOS Project Science Office, Code 900, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771 NW-2002-2-027-GSFC

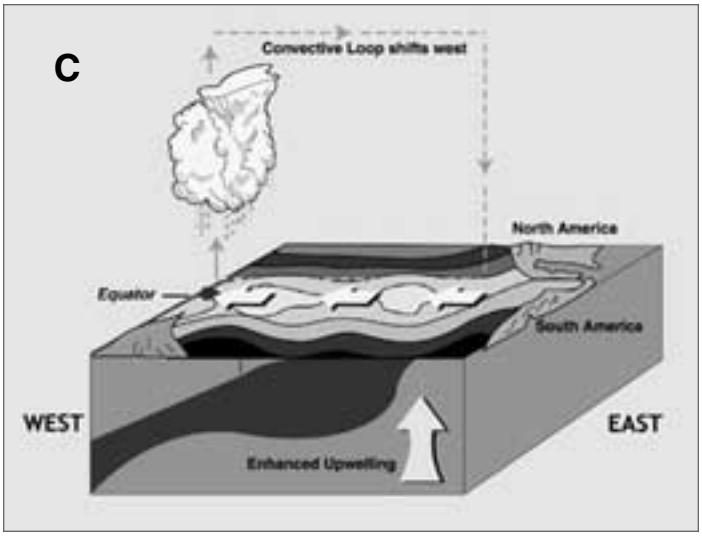
The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

A Closer Look at El Niño and La Niña







In a “normal” year (Figure A), the Trade Winds blow from east to west across the eastern Pacific. They tend to drag the surface waters westward across the ocean. In turn, this causes deeper, colder waters to rise to the surface along the coast. The “upwelling” of deep ocean waters brings with it nutrients that otherwise would lie near the bottom of the ocean. The fish population living in the upper waters is dependent on these nutrients for survival.

During El Niño (Figure B), the westward Trade Winds weaken, causing the upwelling of deep water to cease. The consequent warming of the ocean surface further weakens the Trade Winds, and strengthens El Niño. Without upwelling, the nutrients from the deep water are no longer available for the food chain, which causes a severe reduction in the fishing industry.

During La Niña (Figure C), the Trade Winds are unusually strong due to an enhanced pressure gradient between the eastern and western Pacific. As a result, upwelling is enhanced along the equator, contributing to colder than normal surface waters over the equatorial Pacific.

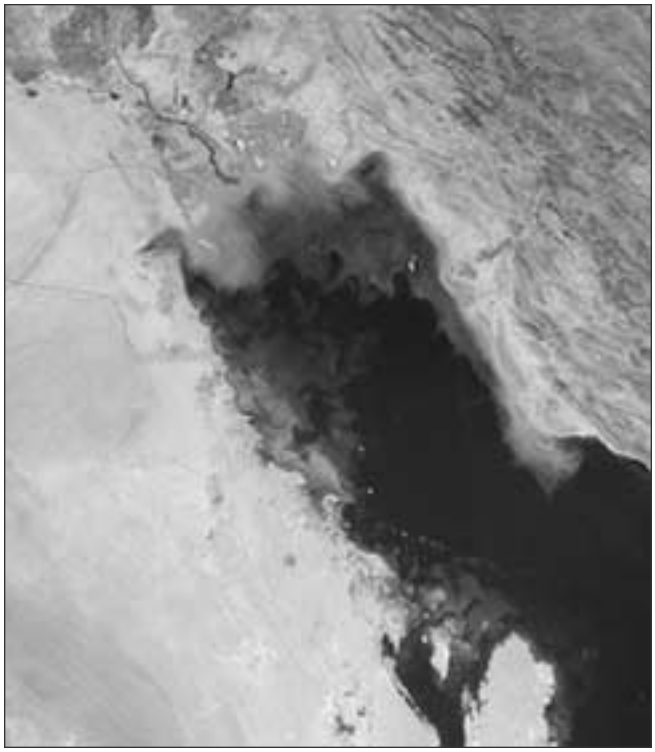
Changes in global atmospheric circulation patterns, caused by El Niño and La Niña, bring about weather extremes in various parts of the world. The effects during El Niño are typically opposite those experienced during La Niña. These patterns result from colder or warmer than normal ocean temperatures enhancing or inhibiting the formation of rain-producing clouds over the eastern equatorial Pacific region while, at the same time, enhancing or inhibiting rainfall over the western equatorial Pacific region (Indonesia, Malaysia and northern Australia.) These patterns disrupt the position and intensity of jet streams and, thus, the behavior of storms outside of the tropics in both the Northern and Southern hemispheres. During El Niño, relocated jet streams contribute to a decrease in tropical cyclone activity in the Atlantic basins. Conversely, during La Niña, the number of Atlantic tropical storms and hurricanes is often higher.

Prediction of El Niño/La Niña events is now the focus of a major scientific initiative. The societal impacts of accurately forecasting El Niño or La Niña up to a year in advance are huge, allowing economic and agricultural policymakers to adapt to short-term climate fluctuations in a beneficial way. Satellite observations will continue to play a crucial role in ensuring the success of these forecasts by providing accurate measurements of the present conditions in the region, an essential first task for prediction.

National Aeronautics and Space Administration
For more information contact: EOS Project Science Office, Code 900, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771 NW-2002-2-027-GSFC

The Earth Science Enterprise
The Earth Observing System *eos.nasa.gov*

For additional information on “Water—The Basis for Life,” consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

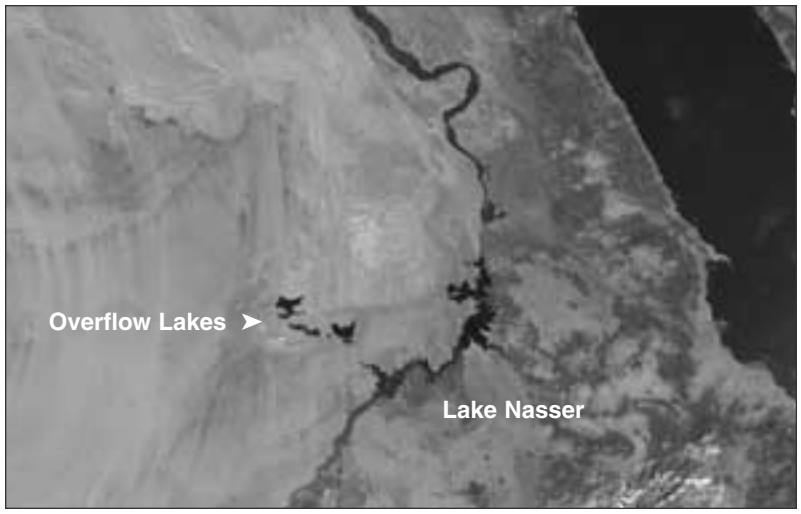


The Persian Gulf

There is a large amount of sediment clearly visible in this image (left) of the Persian Gulf, acquired on November 1, 2001, by MODIS. Carried by the confluence of the Tigris and Euphrates Rivers (at center), the sediment-laden waters gradually dissipate into swirls as they drift southward. The nutrients these sediments carry are helping to support a phytoplankton bloom in the region. The confluence of the Tigris and Euphrates Rivers marks the southernmost boundary between Iran (upper right) and Iraq (upper left). South of Iraq are the countries of Kuwait and Saudi Arabia.

Image credit: Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC

The Birth of Four Lakes



Four lakes formed recently in southern Egypt in an area that was previously desert. Fed by unusually high levels of rainfall and water overflowing from the Aswan High Dam on the Nile River, the first lake appeared in 1998. The Aswan's overflowing waters are channeled through an arroyo into a reservoir, as expected, but as the high rains have continued, so has the overflow. Consequently, the reservoir has grown in size and three more lakes have formed.

Authorities in Egypt estimate that, together, the lakes now hold about 700 billion cubic feet of water—one quarter of the Nile's total water supply. Scientists don't know whether or not the lakes will become permanent, or will dry up within a few years.

In this image obtained from data collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) on October 10, 2000, the lakes are the areas of dark pixels located about 50 kilometers west of Lake Nasser.

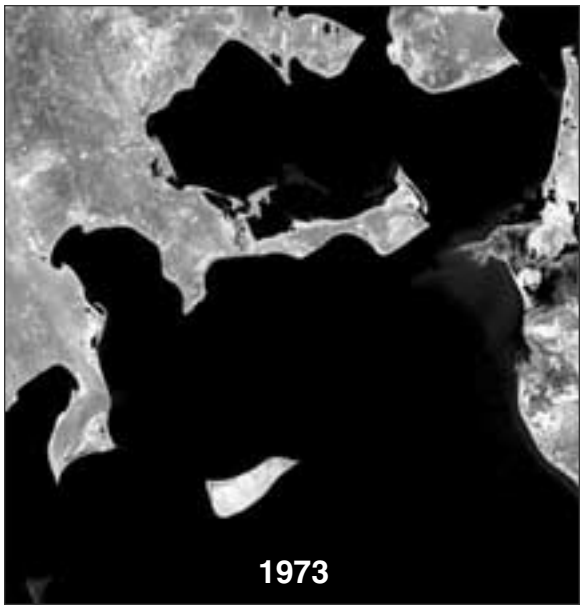
Image credit: Robert Simmon, Reto Stöckli, and Brian Montgomery, NASA/GSFC

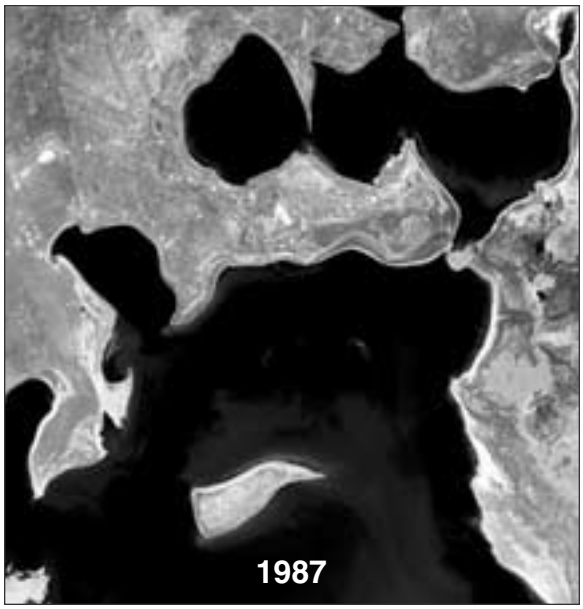
National Aeronautics and Space Administration
For more information contact: EOS Project Science Office, Code 900, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771 NW-2002-2-027-GSFC

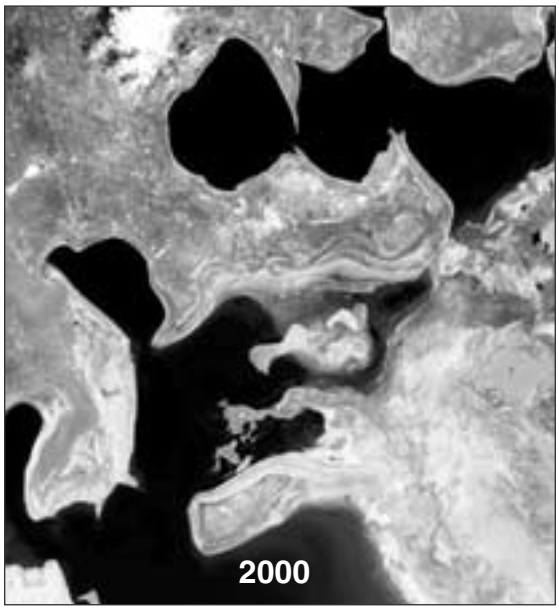
The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

A Shrinking Sea







Large bodies of water have a moderating influence on local climate. They are also extremely important to local ecological conditions, helping to determine which life forms can thrive (or survive) in a particular area. The Aral Sea was once one of the Earth's largest bodies of land-locked water. Since 1960, the sea has lost much of its volume. The associated drop in sea level has lowered the surrounding water table. The depletion of the Aral Sea was caused by the rerouting of two large rivers, major sources of fresh water, for the irrigation of cotton fields.

If the shrinkage continues at the same rate, it is predicted the Aral Sea will disappear altogether by the year 2020. The images above dated 1973 and 1987 are from the Landsat Multi-Spectral Scanner (MSS) and the image dated 2000 comes from the Enhanced Thematic Mapper (ETM+) instrument flying on Landsat 7.

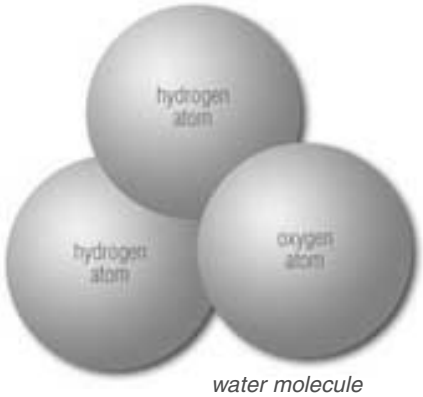
Image credit: U.S. Geological Survey EROS Data Center, based on data provided by the Landsat science team

National Aeronautics and Space Administration
For more information contact:
EOS Project Science Office, Code 900
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
NW-2002-2-027-GSFC

The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

Where Is the Water?



water molecule

	Volume (1000 km^3)	Percent of Total Water	Percent of Fresh Water
Oceans, Seas, & Bays	1,338,000	96.5	–
Ice caps, Glaciers, & Permanent Snow	24,064	1.74	68.7
Groundwater	23,400	1.7	–
Fresh	(10,530)	(0.76)	30.1
Saline	(12,870)	(0.94)	–
Soil Moisture	16.5	0.001	0.05
Ground Ice & Permafrost	300	0.022	0.86
Lakes	176.4	0.013	–
Fresh	(91.0)	(0.007)	0.26
Saline	(85.4)	(0.006)	–
Atmosphere	12.9	0.001	0.04
Swamp Water	11.47	0.0008	0.03
Rivers	2.12	0.0002	0.006
Biological Water	1.12	0.0001	0.003
Total	**1,385,984**	**100.0**	**100.0**

The table above provides a rough indication of the distribution of water in the Earth/atmosphere system. Estimates of groundwater are particularly difficult and vary widely amongst sources, with the value in this table being near the high end of the range. These values indicate that groundwater constitutes approximately 30% of fresh water, whereas ice (including ice caps, glaciers, permanent snow, ground ice, and permafrost) constitute approximately 70% of fresh water.

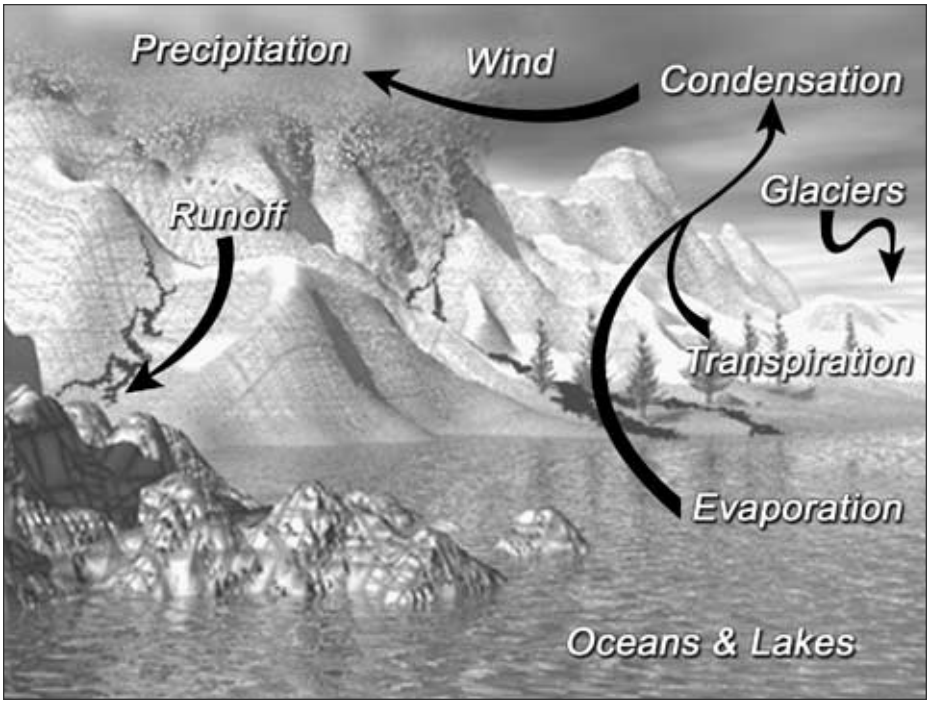
Source: Gleick, P. H., 1996: Water resources. In Encyclopedia of Climate and Weather, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp. 817-823.

National Aeronautics and Space Administration
For more information contact: EOS Project Science Office, Code 900, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771 NW-2002-2-027-GSFC

The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

The Hydrologic Cycle



The hydrologic cycle describes the pilgrimage of water as water molecules make their way through the Earth/atmosphere system. This gigantic system is powered by energy from the sun and is a continuous exchange of moisture between the oceans, the atmosphere, and the land. Studies have revealed that the oceans, seas, and other bodies of water (lakes, rivers, streams) provide nearly 90% of the moisture in our atmosphere. Liquid water leaves these sources as a result of evaporation, the process by which water changes from a liquid to a gas. In addition, a very small portion of water vapor enters the atmosphere through sublimation, the process by which water changes directly from a solid (ice or snow) to a gas. (The gradual shrinking of snow banks, even though the temperature remains below the freezing point, results from sublimation.) The remaining 10% of the moisture found in the atmosphere is released by plants through transpiration.

National Aeronautics and Space Administration
For more information contact:
EOS Project Science Office, Code 900
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
NW-2002-2-027-GSFC

The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/

For the Classroom…

Introduce major concepts of "Water—The Basis for Life" by dividing the class into small teams to research several of the questions below. Students can research their answers using the poster and the Internet links found at the URL below. Students can prepare presentations to cooperatively instruct other teams using pre-established teacher criteria.

- How can a growing population's needs affect nearby lakes or rivers? How can that then affect other population centers far away?
- How can surface temperature over a large area of the Pacific Ocean affect the weather in the eastern United States?
- Can you think of any beneficial effects of a hurricane?
- Name several things that contribute to the depletion of ground water, as well as water in lakes and rivers.

National Aeronautics and Space Administration
For more information contact:
EOS Project Science Office, Code 900
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
NW-2002-2-027-GSFC

The Earth Science Enterprise
The Earth Observing System
eos.nasa.gov

For additional information on "Water—The Basis for Life," consult the following URL: http://nasadaacs.eos.nasa.gov/eosposters/